Fig.1

```
                          ┌─────────┐  ⌒ 22
                          │   CPU   │
                          └────┬────┘
    30                         │                           24
 ┌──────────┐                  │            ┌──────────────────────────────┐
 │ KEYBOARD │◄────────────────►│            │                              │
 └──────────┘                  │            │   MAIN MEMORY      42         │
                               │            │              ┌────────────┐  │
     32                        │            │   ┌──────────────────────┐   │
   ┌───┐                       │            │   │  DIGITAL WATERMARK   │   │
   │   │◄─────────────────────►│            │   │   EMBEDDING UNIT     │   │
   └───┘                       │            │   └──────────────────────┘   │
     34                        │            │                              │
  ╭───────────╮                │            └──────────────────────────────┘
  │  DISPLAY  │◄──────────────►│
  ╰───────────╯                │                      10
                               │                  ┌─────────┐  36
                               │                  │         │
                               │                  │         │
      ┌────────┐               │                  └─────────┘
  39 ─│SCANNER │◄─────────────►│◄────────────────►
      └────────┘               │
                               │                        26
      38                       │            ┌──────────────────┐
  ┌─────────┐                  │            │   FRAME MEMORY   │
NT│  MODEM  │◄────────────────►│◄──────────►└──────────────────┘
  └─────────┘                  │
                               │  ⌒ 40
                               │
                               ▼
     ┌──┐
     │  │─ SV
     └──┘
```

Fig.2

42

MASTER DATA

50 — DISCRETE FOURIER
TRANSFORM UNIT

52 — MINUTE VARIATION
ADDITION UNIT ← WATERMARK
INFORMATION ΔF
$\begin{pmatrix} \text{PHASE DIFFERENCE} \\ \text{PATTERN} \end{pmatrix}$

54 — INVERSE FOURIER
TRANSFORM UNIT

PROCESSED DATA WITH
DIGITAL WATERMARK
EMBEDDED THEREIN

Fig.3

```
   ┌─────────────────────────────┐
   │   PROCESSING ROUTINE TO     │
   │  EMBED DIGITAL WATERMARK    │
   └─────────────────────────────┘
                 │
                 ▼
```

S100 ──── | READ IMAGE P |

```
                 │
                 ▼
```

S110 ──── | DISCRETE FOURIER TRANSFER |

```
                 │
                 ▼
```

S120 ──── | ADD MINUTE VARIATION ΔF |

```
                 │
                 ▼
```

S130 ──── | INVERSE TRANSFORM OF MATRIX F |

```
                 │
                 ▼
```

S140 ──── | OUTPUT DATA |

```
                 │
                 ▼
   ┌─────────────────────────────┐
   │            END              │
   └─────────────────────────────┘
```

Fig.4A

P 0

Fig.4B

P 1

Fig.4C

| W 0 1 |
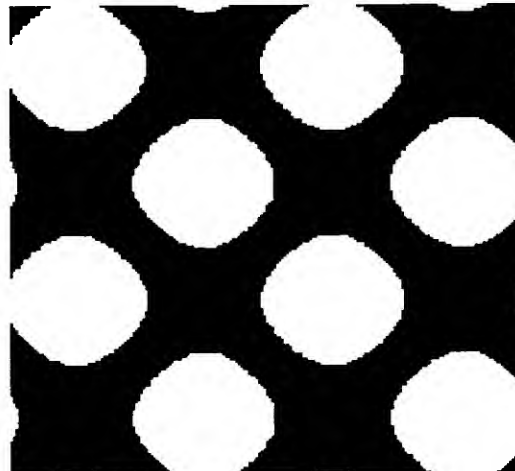
Fig.5A

REAL NUMBER ARRAY FR

	253	254	255	0	1	2	3
253	0.28	-0.12	-0.14	-0.04	0.17	0.09	0.02
254	0.02	0.20	-0.32	0.38	-0.07	-0.23	-0.17
255	0.02	-0.07	-0.35	-0.09	-0.01	0.25	0.22
0	0.13	-0.16	-0.03	6.46	-0.03	-0.16	0.13
1	0.22	0.25	-0.01	-0.09	-0.35	-0.07	0.02
2	-0.17	-0.23	-0.07	0.38	-0.32	0.20	0.02
3	0.02	0.09	0.17	-0.04	-0.14	-0.12	0.28

1.0e+006 *

Fig.5B

IMAGINARY NUMBER ARRAY FI

	253	254	255	0	1	2	3
253	0.21	-1.93	4.74	-1.91	2.72	2.74	0.42
254	-1.47	1.47	0.64	2.49	0.77	-0.82	0.42
255	1.46	0.69	-4.67	-7.07	3.30	-0.19	-2.01
0	-0.80	-0.06	2.85	0.00	-2.85	0.06	0.80
1	2.01	0.19	-3.30	7.07	4.67	-0.69	-1.46
2	-0.42	0.82	-0.77	-2.49	-0.64	-1.47	1.47
3	-0.42	-2.74	-2.72	1.91	-4.74	1.93	-0.21

1.0e+005 *

Fig.6

```
        ┌─────────────────────────────┐
        │   PROCESSING ROUTINE TO     │
        │   ADD MINUTE VARIATION      │
        └─────────────────────────────┘
                      │
                      ▼
S122    ┌─────────────────────────────┐
        │    SPECIFY ELEMENTS OF      │
        │   INTEREST FOR ADDITION     │
        └─────────────────────────────┘
                      │
                      ▼
S124    ┌─────────────────────────────┐
        │    SPECIFY MAGNITUDE OF     │
        │   MINUTE VARIATION ΔF       │
        └─────────────────────────────┘
                      │
                      ▼
S126    ┌─────────────────────────────┐
        │   ADD MINUTE VARIATION ΔF   │
        └─────────────────────────────┘
                      │
                      ▼
        ┌─────────────────────────────┐
        │            END              │
        └─────────────────────────────┘
```
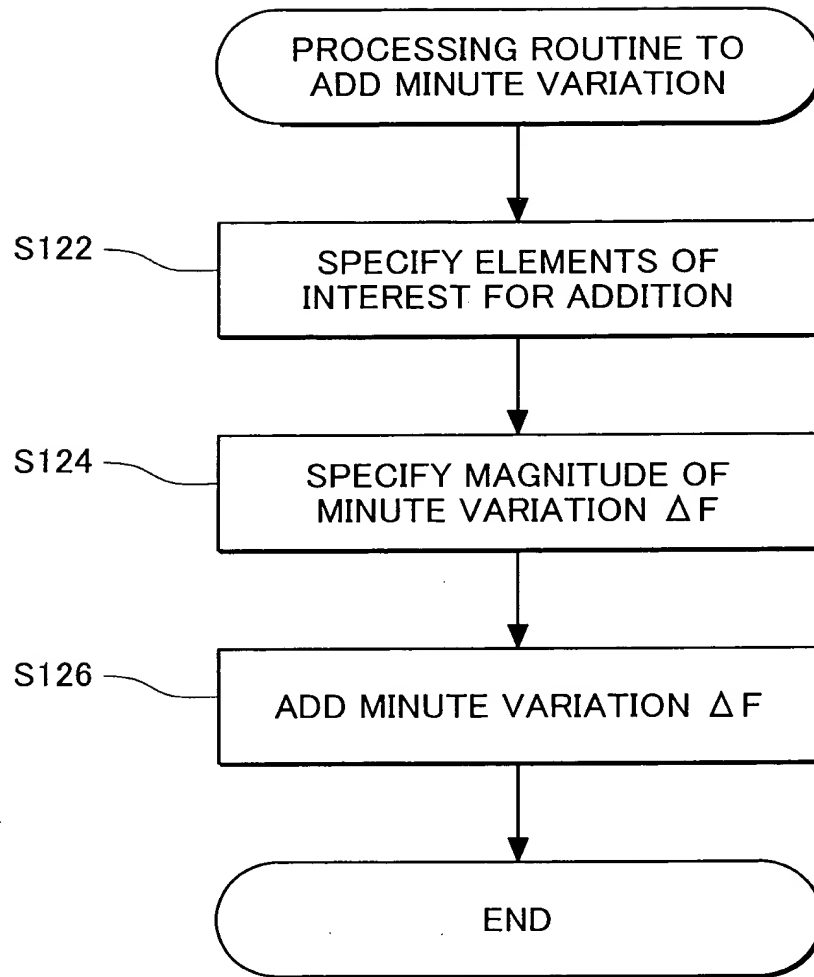
Fig.7A

| W01 |
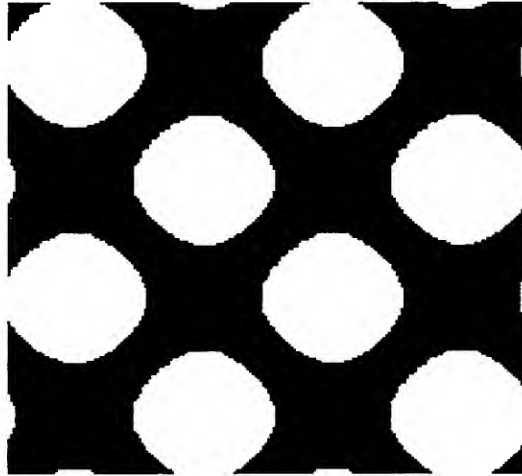
Fig.7B

| W' 01 |
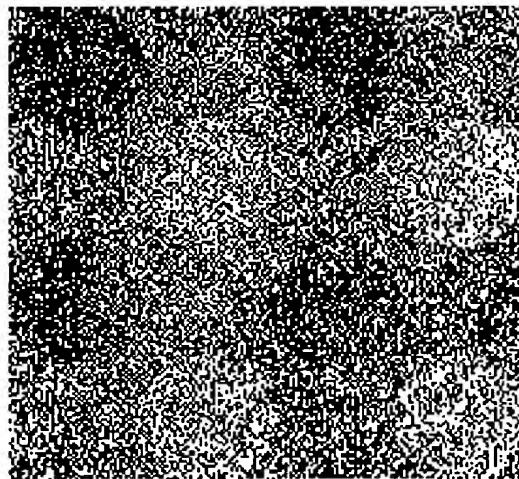
Fig.8A

| W01 |
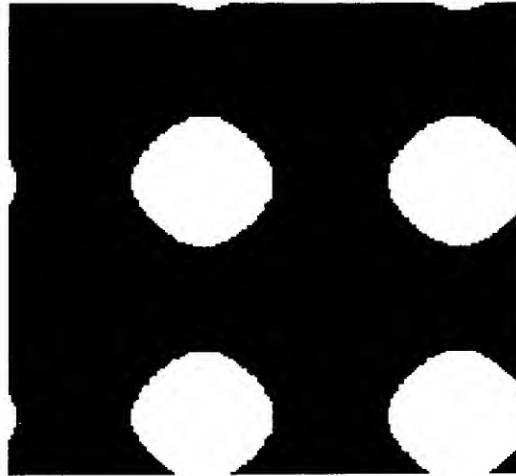
Fig.8B

P'1

Fig.8C

| W' 01 |
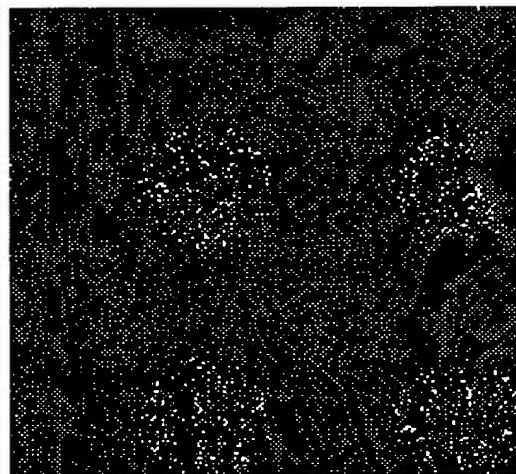
Fig.9A

| W01 |

Fig.9B

P' 1

Fig.9C

| W' 01 |

Fig.10

(a) P₀   S₁ →   (b) P₁   S₂ →   (c) P₂

(d) $|W_{01}|$ (e) $|W_{02}|$ (f) $|W_{12}|$ (g) $|W_{02} - W_{12}|$

Fig.11

42

MASTER DATA

↓

60 — DATA COMPRESSION UNIT

↓

62 — DISCRETE FOURIER TRANSFORM UNIT

↓

64 — MINUTE VARIATION ADDITION UNIT

↓

66 — INVERSE FOURIER TRANSFORM UNIT

↓

68 — DATA DECOMPRESSION (EXPANSION) UNIT

↓

PROCESSED DATA WITH DIGITAL WATERMARK EMBEDDED THEERIN
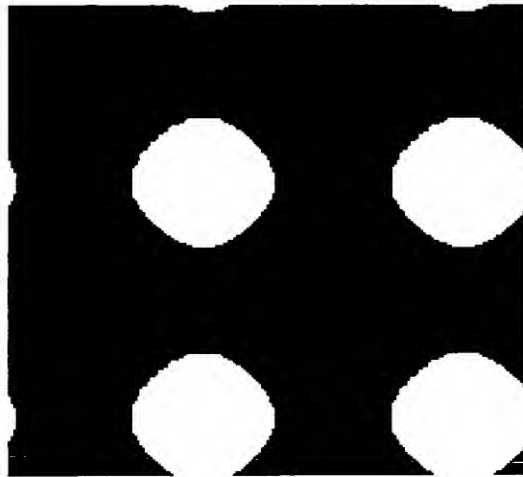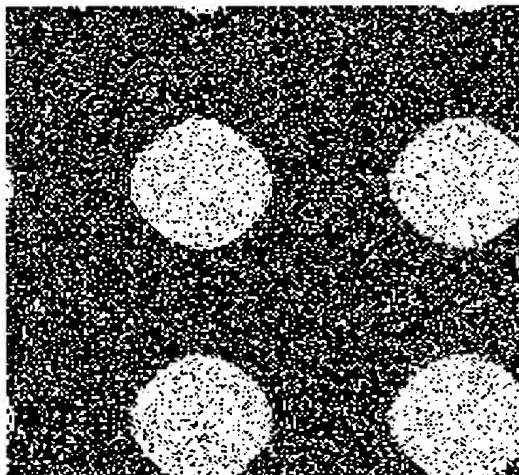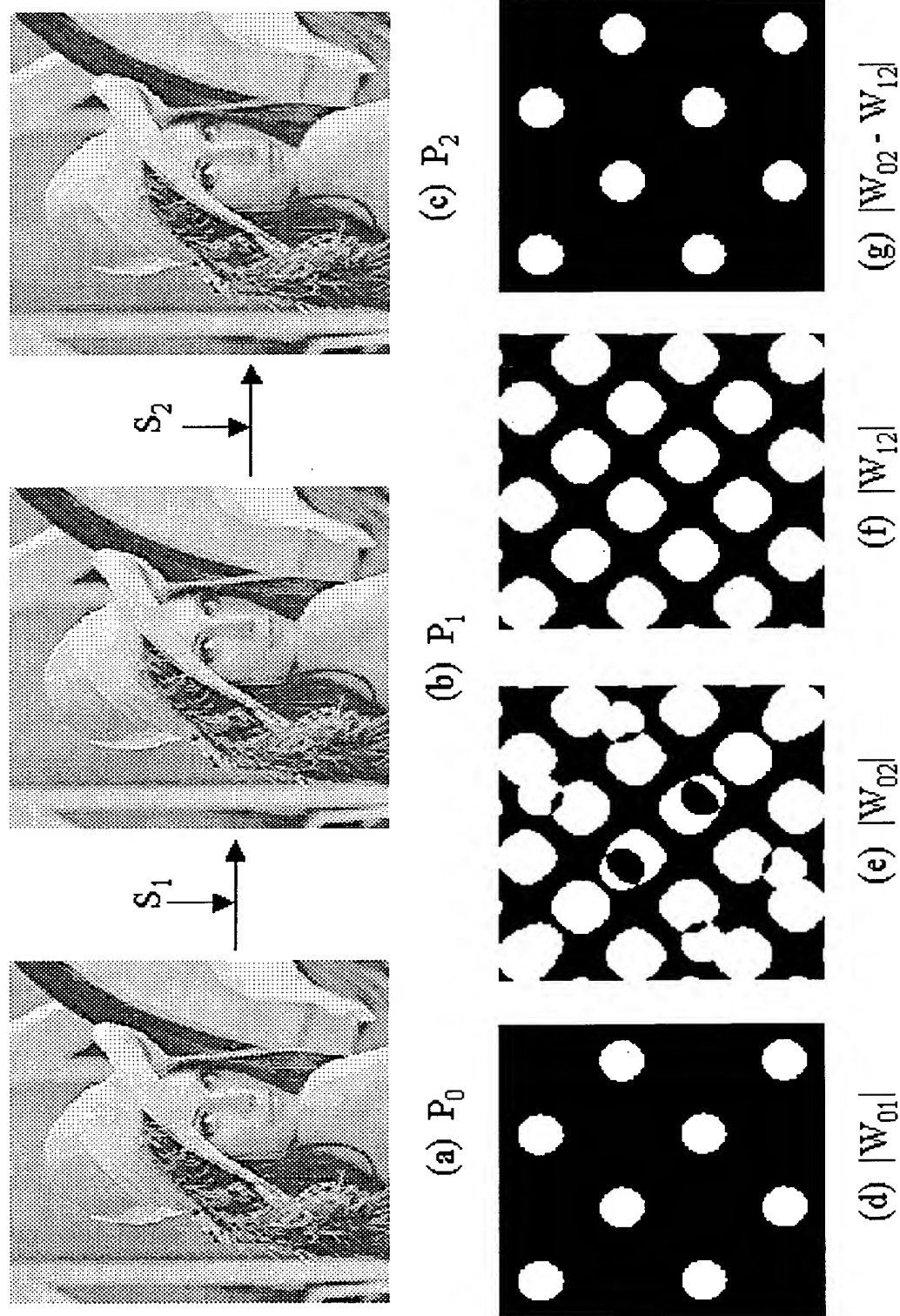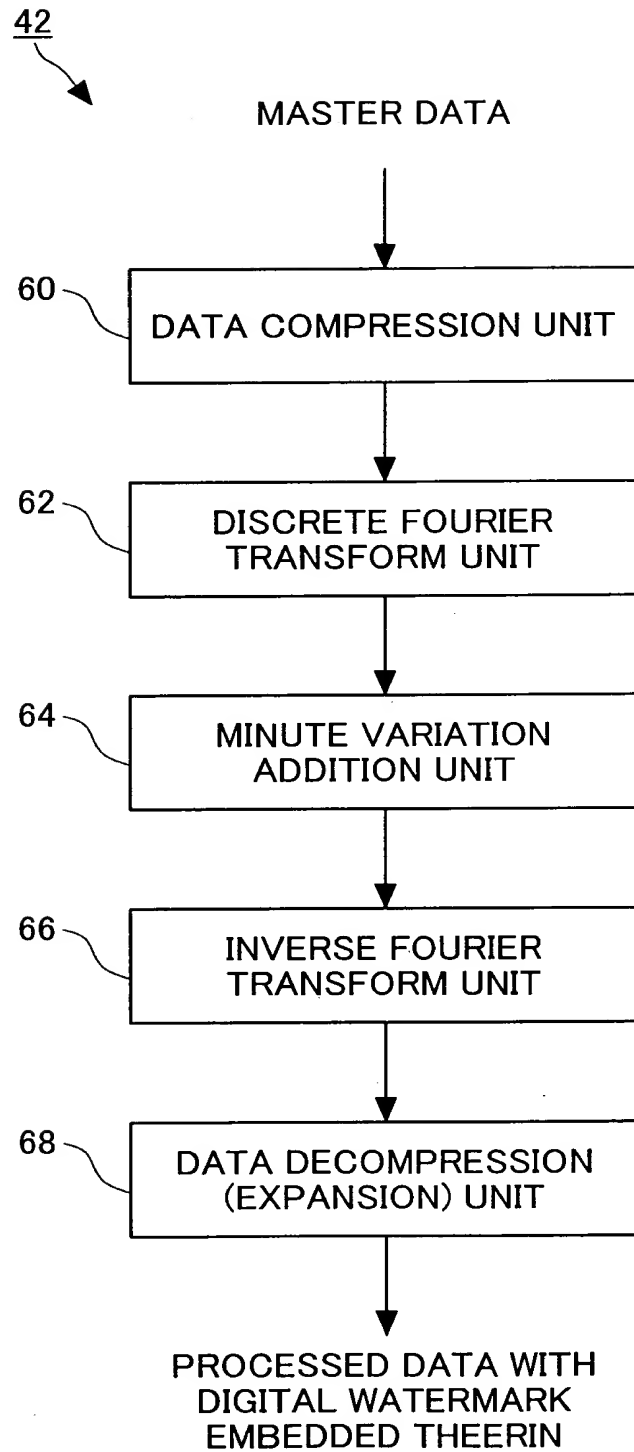
Fig.12A

I_0	I_3
I_1	I_2

PIXEL AREA

Fig.12B

w_0	w_1
w_2	w_3

TRANSFORMED AREA

Fig.13

Fig.14

PROCESSING ROUTINE TO
EMBED DIGITAL WATERMARK

S200 — READ IMAGE P

S210 — WAVELET TRANSFORM

S220 — DISCRETE FOURIER TRANSFORM

S230 — ADD MINUTE VARIATION ΔF

S240 — INVERSE TRANSFORM
OF MATRIX F

S250 — INVERSE WAVELET TRANSFORM

S260 — OUTPUT DATA

END

Fig.15

L L 2
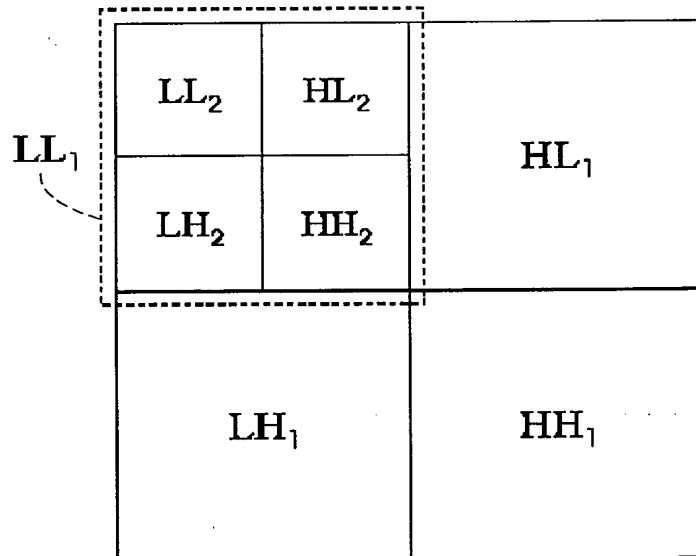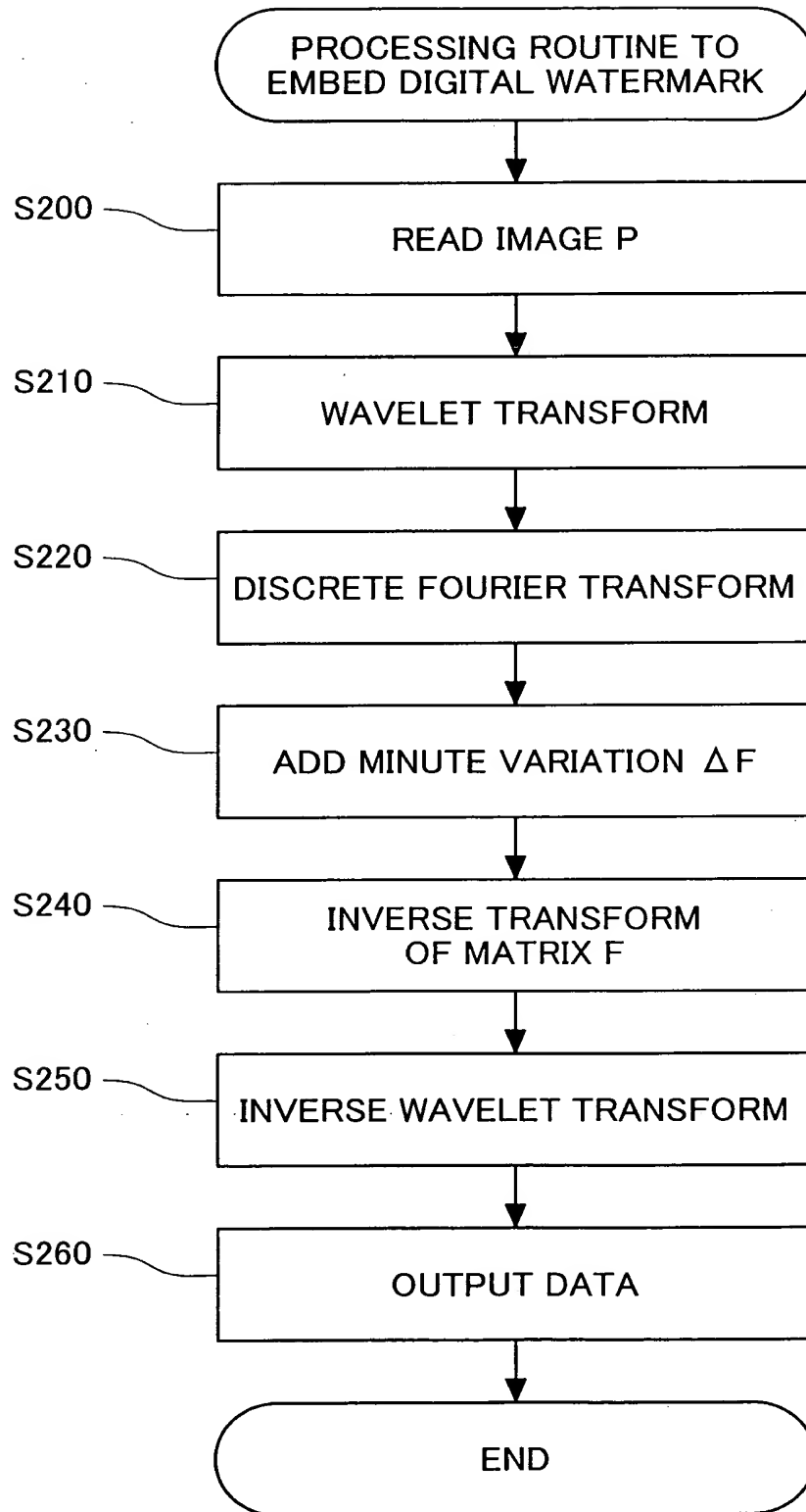
Fig.16A   *Fig.16B*

PROCESSED IMAGE WITH
EMBEDDED PATTERN

PHASE DIFFERENCE
PATTERN

Fig.17A

Q0

S1

Fig.17B

Q1

S2

Fig.17C

Q2

Fig.17D

| W01 |

Fig.17E

| W02 |

Fig.17F

| W12 |

Fig.17G

| W02−W12 |

Fig.17H

Q3
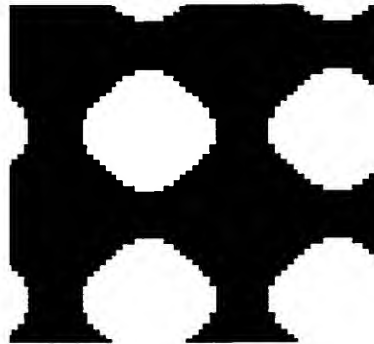
Fig.17I

| W03 |

Fig.17J

	254	255	0	1	2
254	0.00	0.00	0.00	0.00	0.00
255	0.00	0.00	0.00	0.00	0.00
0	0.00	0.00	0.00	0.00	-3.00
1	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	-3.00	0.00	0.00

$$1.0 \quad e+004*$$

$$|S1-S3|$$
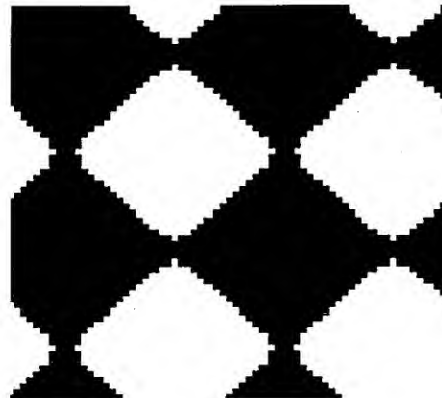
Fig.18A

Δ＝5．0＊10 e 2
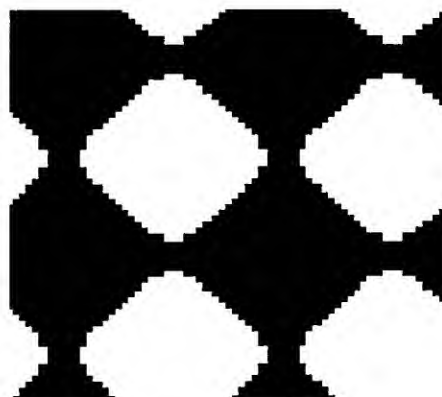
Fig.18B

Δ＝3．0＊10 e 2

Fig.18C
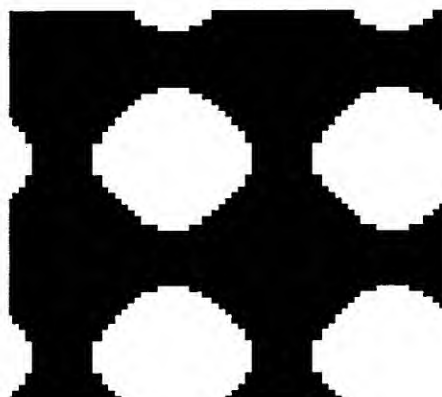
Δ＝1．0＊10 e 2

Fig.19A

W01

Fig.19B

Q' 1

Fig.19C
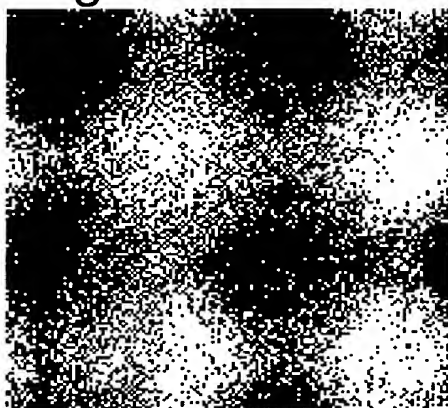
W' 01

Fig.19D
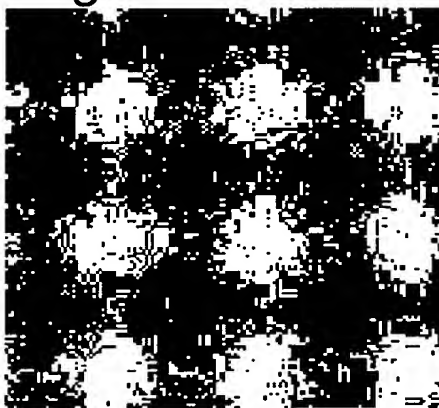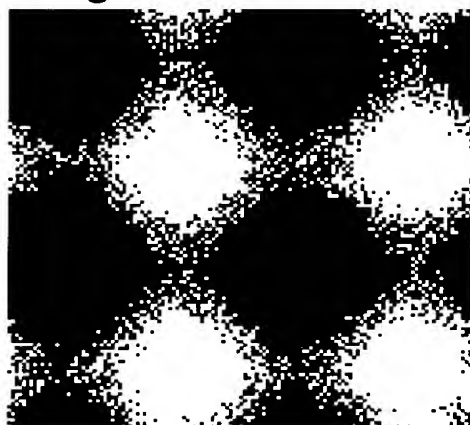
W" 12

Fig.19E

W' 02

Fig.19F

W' 12

Fig.20A

W01

Fig.20B

Q' 1

Fig.20C

W' 01

Fig.20D

W"12

Fig.20E

W' 02

Fig.20F

W' 12
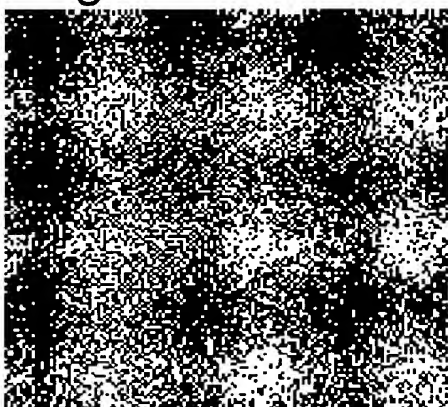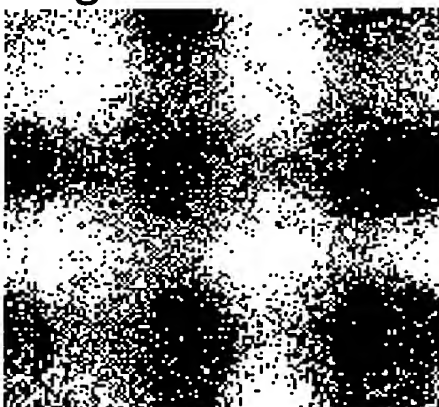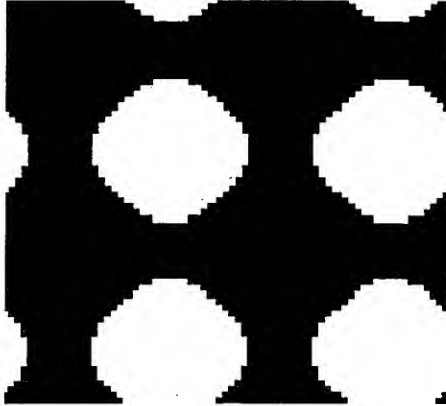
Fig.21A

W01

Fig.21B

Q' 1

Fig.21C
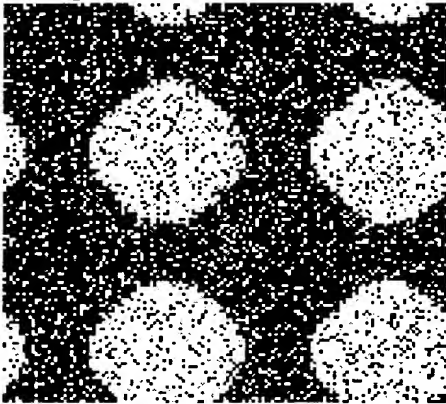
W' 01

Fig.21D
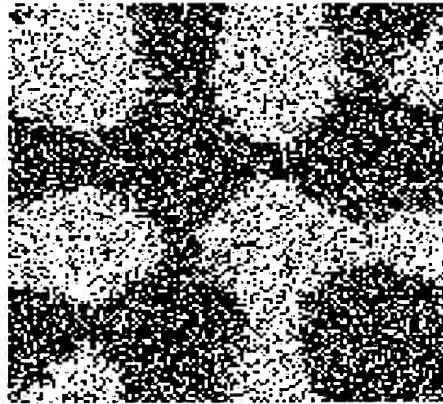
W″12

Fig.21E
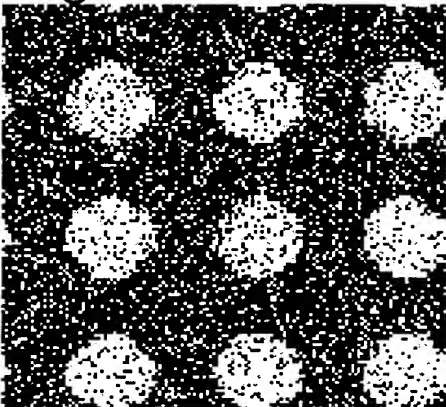
W' 02

Fig.21F
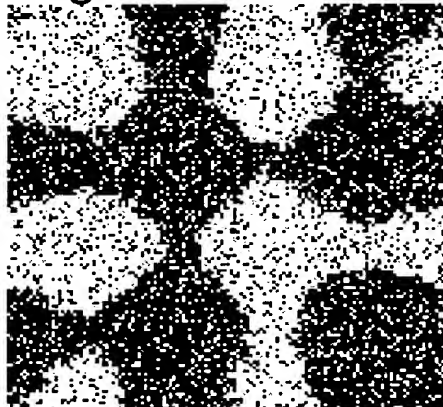
W' 12

Fig.22A

W01

Fig.22B

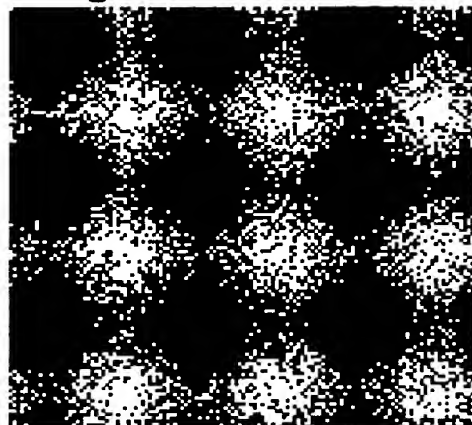
Q'1

Fig.22C

W' 01

Fig.22D
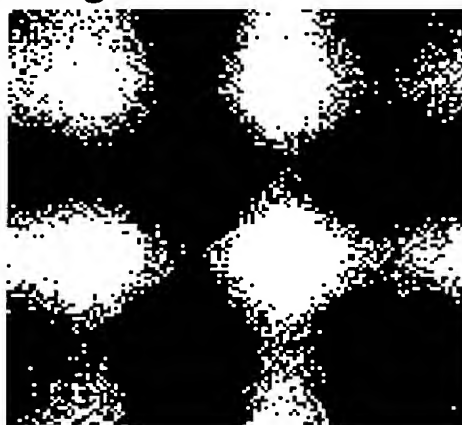
W"12

Fig.22E

W' 02

Fig.22F

W' 12